Factors of reuse of Units of Learning Material

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Abstract
A hypothetical model of the factors that influence reuse of digitally stored learning material is proposed. The causal relations of the model are examined, and for some evidence can be found by reasoning and from the literature. For other relations, however, empirical research may be needed.

1 Introduction

The past few years, computers are more and more capable of handling real-time video- and audiostreams. One of the many application areas is education, and especially digital learning environments which provide the learner with a large collection of learning materials; both audiovisual and textual. The audiovisual material is quite expensive to produce: one has to write multimedia scripts, hire a camera crew, digitize and edit the material, and enter it into the digital system. Obviously, the more often we can (re)use this material for other purposes, the more cost-effective it is. In this article, we will explore the factors that influence reuse, and examine their causal relations.

2 Situational context

The model we will present in Section 4 assumes the existence of digital learning material, in the form of audiovisual sequences (eg. QuickTime or MPEG movies), or active objects written in Java or Authorware for example. The learning material, which is labeled and stored in a database

system, can be retrieved by teachers to compose material for their lessons. The learners can "play" these compositions, retrieving one object at a time and interacting with it. The database would be able to store any results, although this could also be stored elsewhere.

3 Definitions

In order to avoid ambiguity, we will first define the factors used in the model.

3.1 Unit of Learning Material

The concept of a Unit of Learning Material as described by Hiddink (1997) states that a ULM is a collection of digital learning material that has been declared to be an educational unit by a teacher. A ULM is provided with educational labels ...

3.2 Reuse

We will define reuse as using a ULM in more than one educational situation. These situations can differ in the course being taught, the person teaching the course, the institution where the course is taught, etcetera.

3.3 Labeling system

A labeling system is defined as a collection of *label names* (such as "creator", "educational objective", "educational level") that can be given to a ULM. A label name can have preconditions, such as *each ULM must have at least one value for this label* or *a ULM can have zero or more values for this label.* Also, the value range for each label is determined (for example, the range of educational levels can be defined to be in the range of 1 to 10).

3.4 Accessability

Accessability is an abstract measure of the capability of a ULM to be accessed. For example, a ULM which has empty values for all labels and no relations to other ULMs is not likely to be found by the user. On the other hand, if this ULM which has values for all labels and relations to many other ULMs, it is more likely to be found using the same search criteria as in the first situation. It is this likelyhood that we call *accessability.*

3.5 Reusability

Reusability is another abstract measure, it defines the potential of a ULM to be reused.

3.6 Subject matter commonalities

Subject matter commonalities is the amount of subject matter that two or more courses have in common. This amount can be expressed in two ways:

semantical content: the amount of (some kind of) semantical units that the courses have in common, for example the number of subjects (at a certain level of granularity). Methods for counting semantical units are described in ....

syntactical content: the amount of syntactical units that the courses have in common, for example the number of words in a text and the duration of the video fragments.

These two measures will be strongly related, as two courses that have a lot of semantical content in common will also have a lot of syntactical content in common. This depends, however, on how the syntactical content has been designed.

3.7 Search method

The *search method* is the method with which the database is searched for learning material with certain characteristics. A few examples are:

- using a form to ask the user what the desired characteristics are and then querying the database for material that has those characteristics;
- using a list of (hierarchical) subject matter areas the user can browse;
- using interrelationships of the Units of Learning Material to find material that is related to a certain usable ULM.

3.8 Usage

Each ULM keeps a record of its usage: which courses it is currently used in, which courses it has been used in in the past, etcetera. Another way to describe the same information is: the learning material of all courses currently in current and in past use. The *usage* factor is the number of courses the ULM is, and has been part of.

3.9 Genericity

Genericity of a ULM is an inverted measure of the amount of specific details in the contents of the ULM. For example, a ULM that displays a field of green grass can be used in a lot of courses: courses about american football, about growing certain kinds of grass, or about the process of plants absorbing sunlight so that they look green. On the other hand, a ULM which displays a field of green grass suddenly crossed by one ball and twenty soccer players can hardly be reused for explaining sunlight absorption. We define the measure of reusability of the first ULM to be larger than that of the second, as the second ULM has more specific details: a ball and twenty soccer players.

3.10 Context adaptors

An important concept when reusing Units of Learning Material is the *context adapter*. Imagine that a teacher is preparing a course on differential equations, and that the teacher wants to give some examples to make the course more vivid. The teacher has found an audiovisual presentation of a simulated neural network that is capable of learning how to drive a truck backwards to a loading dock (by trial and error). The neural network uses complicated differential equations in order to use the error after a try to update its internal state. However, in the explanation, some references are made to the internal structure of the neural network. The teacher does not want his or her students to be confused by this, so the teacher wants to have a little text that adapts the context of the course on neural networks to the context of a mathematics course by saying "Pay particular attention to the differential equations, and please ignore the text about the internal structure". We will call such a text a *context adaptor*.

3.11 Human Factor

The Units of Learning Material are labeled and entered by human beings. If these humans do not label the ULMs properly, then the accessability of the ULMs will not be very high. The humans may have various reasons for not labeling properly (laziness, miscomprehension, usage errors); we will not go further into this but we will acknowledge the effect of these human factors on the accessability of the learning material.

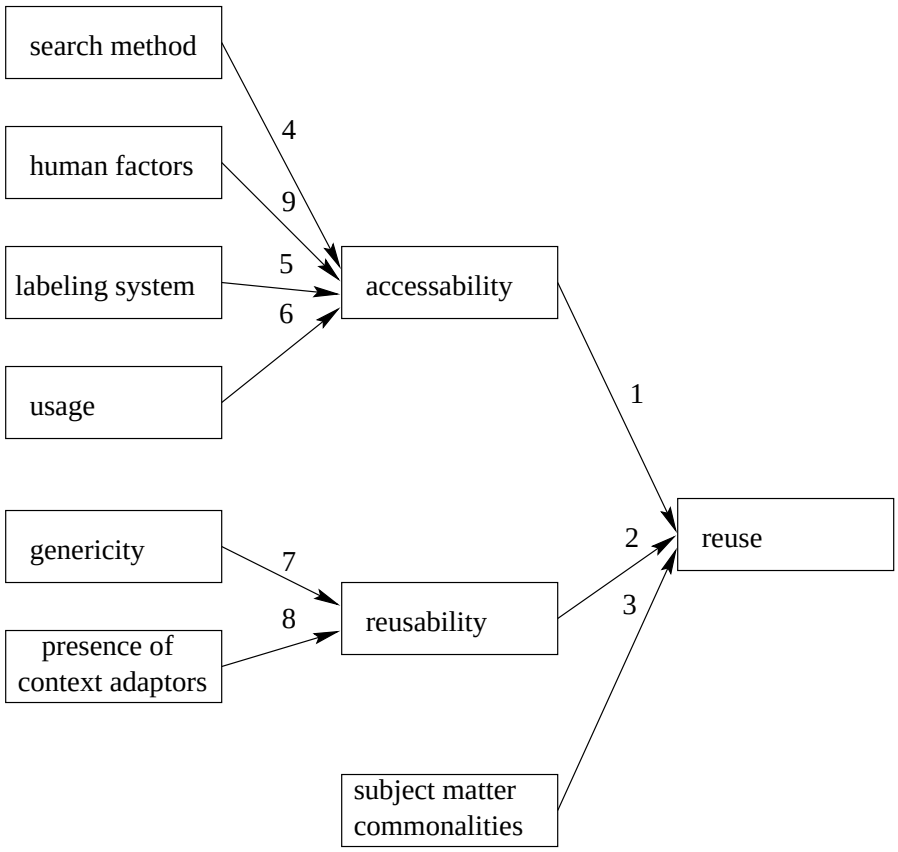

Figure 1: The FORMULA-M model: Factors Of Reuse of MUltimedia LeArning Material

4 Model

The factors introduced above can be placed in a causal relationship diagram, which is depicted in figure 1. We will discuss the numbered relationships one by one below. Note that the discussion is purely hypothetical; the propositions made will have to be validated using impirical or literature research.

1. The amount of actual reuse is related to the accessability of a Unit of Learning Material: if a ULM is not accessable, then the user will not be able to find it in the database, and will not be able to reuse it in another situation. Also, a ULM that can be accessed easily, will be

more likely to be reused than one that is not easy to access. However, a ULM that is reused often *may* have a low accessability. So we can conclude that a high accessability is a possible cause of actual reuse.

2. The amount of actual reuse is also related to the potential of a ULM to be reused: a ULM that is by its nature better suitable to be reused, will be reused more often than a ULM that is less suited for reuse. However, a ULM that is reused often *may* have a low reusability. So we can conclude that a high reusability is a possible cause of actual reuse.

3. The amount of subject matter commonalities also determines how much reuse we can expect: if two courses do not have any subject matter in common, then there will be very few opportunities to reuse learning material. If, on the other hand, two courses are almost the same, then a lot of learning material for one course can be expected to be reused in the other.

4. The search method influences the accessability of a ULM: if we would have the perfect search method, then we would be able to find everything we would need, and thus every ULM would have a high accessability. On the other hand, if we have a lousy search method, then we cannot find anything, and all ULMs would have a low accessability. And as a high accessability does not imply a good search method, we can conclude that the quality of the search method causes a high accessability.

5. The labeling system determines the accessibility of a ULM: if the labeling system does not function properly, then we may not be able to find ULMs back no matter how well the search method was written. On the other hand, if the labeling system is perfect (using the same search method) then we will be able to find many more ULMs. Thus, the accessability of the ULMs is increased, and we can conclude that the labeling system is positively related to the accessability of a ULM.

6. The usage of a ULM can, when the search method makes use of this information, increase the accessability of a ULM: if a ULM A has been used in a certain old course together with ULM B, and if a teacher has found ULM B to be very useful in a new course, then he or she may examine the contents of the old course and also find ULM A. Without the usage information, this would not have been possible. It is obvious

that the more usage information is present, the more the accessability of the ULM increases. So we can conclude that the amount of usage information is positively related to the accessability of a ULM.

7. One of the key factors for the reusability of a ULM is its genericity: a ULM that is generic, i.e. it has not much specific details, is more reusable than a ULM that has a lot of specific details. The latter just doesn't "fit" into as many situations as the first.

8. The presence of context adaptors can increase the reusability of a ULM: suppose a teacher has found a ULM that would have been reusable, however a recorded voice in the contents of the ULM talks about something that the teacher thinks will confuse the learners. Without a context adaptor, the ULM cannot be reused. *With* the context adaptor, however, the teacher can warn the learners to ignore a particular fragment of the recorded voice, so that the learners will not get confused. The teacher may then decide to reuse the ULM. So we can conclude that the presence of context adaptors increases the reusability of a ULM.

4.1 Empirical research

Some of the relations presented above may need further empirical research.

What may be more interesting, however, is to research how large the influences of the factors are, and if we can explain all variances.

5 Conclusion

References

Hiddink, G. W. (1997). Developing the concept of units of learning material in multimedia educational databases.